

## WATER SYSTEM DESIGN CHAPTER

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## **WATER SYSTEM DESIGN CHAPTER**

### **1.0 GENERAL**

#### **1.1 Introduction**

This chapter of the Brunswick Design Manual outlines the policies, minimum design criteria and design procedures for the preparation of feasibility reports and construction plans and specifications for City-maintained and on-site water system improvements. Developers and/or Design Engineers shall check with the City Public Works, City Engineer, and the Office of Planning and Zoning to determine the availability of water at the site of a proposed subdivision. In the event a conflict exists between requirements, the more stringent applies.

##### **1.1.1 City Policy**

###### **a. City-Maintained Facilities**

The parts of the water supply system which are considered as the property and responsibility of the City of Brunswick are the water mains, appurtenances and that portion of the water services up to and including the curb stop or valve just inside the property line. The water supply and distribution system within the City's rights-of-way and easements for Brunswick is maintained by the City of Brunswick.

###### **b. On-Site Facilities**

The parts of the water services which lie within private property are the responsibility of the owner and are constructed and maintained by the Owner.

###### **c. Requirements for Water Service**

1. All properties will be connected to the water system of Brunswick.
  - a) Each building shall be serviced by a separate water tap. Multiple dwelling units such as an apartment dwelling, duplex or residential unit with apartment(s) may be served by a single water tap.
  - b) If an additional building is constructed on an existing lot which has a water tap, the new structure must be provided with an additional water tap.

- c) If a lot containing more than a single structure is subdivided to provide separate lots for each structure, the lot(s) without water tap(s) must provide these taps as a condition of subdivision.
  - d) If a lot containing a single structure is subdivided, each structure erected upon the new subdivided area must procure a water tap prior to obtaining a building permit.
- d. All public and private water lines shall be inspected by the City of Brunswick, in accordance with City Inspection Procedures and the City Water & Sewer Rules & Regulations, at the expense of the developer.

#### 1.1.2 Definitions

- a. Service Connections: Water mains connecting the distribution mains to individual homes, buildings, or facilities for both consumptive use and fire protection.
- b. Distribution Mains: Water mains connecting the transmission mains to the service connections. The distribution mains provide area-wide fire protection. Generally, the distribution mains will be in a grid or branched configuration.
- c. Transmission Mains: Large diameter mains connecting the treatment plant with the distribution mains.
- d. Average Day Demand: Average day demand is the volume of water used in the year divided by 365.
- e. Average Day Rate (Average Day): Average day rate is the average day demand volume divided by a one-day period, expressed in gallons per minute (gpm) or million gallons per day (MGD).
- f. Maximum Day Demand: Maximum day demand is the largest volume of water used in one day during the year.
- g. Maximum Day Rate (Max. Day): Maximum day rate is the water used during the maximum day divided by a one-day time period expressed in gpm or MGD.
- h. Peak Hour Demand: Peak hour demand is the largest volume of water used in one hour.

- i. Peak Hour Rate (Peak Hour): Peak hour rate is the peak hour demand volume divided by 60 minutes, expressed in gpm; or multiplied by 24 hours, expressed as MGD.
- j. AWWA: American Water Works Association.
- k. City: Mayor and Council of Brunswick.
- l. Fire Flow: Rate of flow to allow for adequate suppression of a fire as suggested by the Insurance Service Office (ISO) or local fire officials.

## **2.0 DESIGN CRITERIA**

### **2.1 General**

For the Engineer's guidance, below are listed major elements constituting the design of a Water Main Utility Design project:

- a. Pipe size and alignment
- b. Profile, with all elevations
- c. Property data (lot dimensions, all sides of affected properties, liber/folio number, owner)
- d. Rights-of-way
- e. Specifications and notes
- f. Cost estimate

### **2.2 Demands**

- a. The sizing of major components of the City water supply system such as major transmission mains, water treatment plants, storage facilities, and booster pumping facilities, are the responsibility of the City and beyond the scope of this manual. The City may require developers to design these facilities as well as finance and construct them. Should this be the case, the City must be consulted for specific design criteria and ultimately review and approve the plans.
- b. The design engineer who is responsible for the extensions of distribution mains shall follow the guidelines in this manual for the derivation of design flows. The calculation of water demands will usually require extension of the average daily rate for the facility, application of a peaking factor to derive the maximum daily rate, then addition of the fire flow requirement.

- c. Generally, the design engineer will be selecting distribution mains of 12-inch diameter and smaller, and often will be required to provide the minimum size mains, which are listed later in this Chapter.

#### 2.2.1 Residential Demands

Studies have shown that the quantity of average daily water use and peaking factor for residential areas are related to lot size. This is due to increases in persons per dwelling unit, per capita consumption, and greater lawn sprinkling as the lot sizes increase. The information in Appendix A shall be used to derive residential demands and peaking factors.

#### 2.2.2 Commercial and Industrial Demands

The estimation of average daily water consumption and peaking factors for commercial demands are greatly dependent on the type of facility. With the exception of industries using process water, the fire demand generally is the major component of the design used to size distribution main extensions and service connections to buildings having sprinkler systems. The design engineer shall refer to the Frederick County plumbing code for derivation of building design flows if the number of fixture units is known. If the type of business is known, but a specific fixture count is not known, use Appendix D to estimate water demand. For undeveloped land, use Appendix A to derive Commercial and Industrial water demand according to zoning.

#### 2.2.3 Fire Flow Rates

##### Residential: <sup>1</sup>

Single Family	1,000 gpm at 25 psi residual
Cityhouses	1,500 gpm at 25 psi residual
Garden Type Apartments	2,000 gpm at 25 psi residual
High Rise Apartments	2,500 gpm at 25 psi residual

##### Commercial: <sup>1</sup>

Regional Shopping Centers	3,000 gpm at 25 psi residual
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##### Industrial: <sup>1</sup>

3,000 gpm at 25 psi residual
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##### Institutions: <sup>1</sup>

Hospitals	2,500 gpm at 25 psi residual
Schools	2,500 gpm at 25 psi residual
<u>Office Building Complex:</u> <sup>1</sup>	3,000 gpm at 25 psi residual

<sup>1</sup> Above fire flows to be used in the absence of site specific data from fire underwriters or construction plans which would permit a determination of fire flow requirements using insurance industry standards (Insurance

Services Office -ISO). Consideration will be given to reducing the requirement where proposed construction includes sprinkler system; refer to current ISO recommendations.

## 2.3 Hydraulic Computations

### 2.3.1 General

The hydraulic design of water mains shall be in accordance with the requirements of the American Water Works Association or Pipeline Design for Water and Wastewater, ASCE, 1975, and the additional guidelines and criteria in this Chapter.

### 2.3.2 Design Flows and Residual Pressures

- a. Service connections, distribution mains and transmission mains shall be sized based on the following design flow rates and residual pressures:

Maintain a minimum of 25 psi at ground level anywhere in the system under all conditions.

or

Normal working pressure of 60 psi and not less than 35 psi residual pressure at the service connection during peak hourly rate.

The City Engineer and/or Public Works Director will determine which criterion is more critical.

- b. In some locations, the main size will be determined by the flow rate required to refill a storage facility which may be more critical than the above requirements. The City will identify this requirement, if applicable.

### 2.3.3 Flow Velocities

Although the flow velocities and direction may vary considerably in distribution mains, there are upper and lower velocity bounds that indicate to the design engineer that design weaknesses may exist. The following are useful guidelines:

- a. Velocities greater than 7 fps at design flow

This condition may produce large friction losses and high potential for valve and joint damage due to water hammer.

- b. Velocities less than 0.5 fps at design flow

This condition indicates that the main may be oversized. Future maintenance problems may result from siltation at valves and there may be

water quality degradation.

#### 2.3.4 Hazen-Williams "C" and Minor Losses

- a. The total head loss at the point of discharge for design flows shall be the sum of both friction and minor losses. The elevation difference between the source and discharge point shall be algebraically added to the total head losses.
- b. Head losses for new pipes shall be computed using the nomograph in Appendix C and the following coefficients:

<u>Type</u>	<u>Pipe Diameter</u>	<u>Hazen-Williams "C"</u>
Service Connections		
Copper	3/4 inch - 3 inch	130
DIP	3 inch	100
Distribution Mains		
DIP	4 inch - 8 inch	100
DIP	10 inch - 12 inch	110
DIP	16 inch - 24 inch	120
Transmission Mains		
DIP	16 inch - 20 inch	120
DIP	24 inch and larger	130

- c. Minor losses due to fittings and valves shall be included as equivalent lengths of pipe as shown in Appendix E or as fractional losses in velocity head as described in Pipeline Design for Water and Wastewater, ASCE, 1975, or other hydraulics texts.

### 2.4 Distribution System Layout and Sizing

#### 2.4.1 General

- a. Extensions of distribution mains will normally be on a grid basis with interconnecting nodes at street intersections.
- b. In Existing Developments with Curbs

In existing developments with curbs, water location shall generally be the same as in new subdivisions. The location of other existing and proposed utilities shall be fully considered.

c. In Existing Developments with Pavement and No Curbs

In existing developments without curbs, water mains shall generally be located four feet outside of the edge of pavement, except that the water main shall not be located under a future curb. The location of other existing and proposed utilities shall be fully considered.

d. In Parks and Public Rights-of-Way

Where location of water would require removal of or damage to trees within parks or public rights-of-way, design engineers shall obtain approval of the City of Brunswick for water alignment and trees to be removed.

e. Easements

All water utility easements shall be 30 feet minimum width. No other utilities will be allowed in the water utility easement without the City of Brunswick's permission.

2.4.2 Residential Subdivision (New and Existing)

The water distribution system for residential areas where fire protection is to be provided shall meet the following criteria:

- a. Minimum size of water mains shall be 8-inch.
- b. All water mains shall be looped, except where capped for future extension to adjoining property. A fire hydrant shall be placed at the end of the main and may be relocated at the time the main is extended, if approved by the City Public Works, City Engineer, and the Office of Planning and Zoning.
- c. A fire hydrant shall be placed within ten (10) feet of the terminus of all dead end mains.

2.4.3 Commercial and Industrial Areas

The water distribution mains for Commercial and Industrial areas where fire protection is to be provided shall meet the following criteria:

- a. Minimum size shall be 8 inches.
- b. All water mains shall be looped, except where capped for future extension to adjoining property. A fire hydrant shall be placed at the end of the main

and may be relocated at the time the main is extended, if approved by the City Public Works, City Engineer, and the Office of Planning and Zoning.

- c. A fire hydrant shall be placed within 100 feet of the terminus of all dead end mains.
- d. Where design flow rates exceed 1500 gpm, hydraulic computations shall be provided.

## 2.5 Service Connections

### 2.5.1 General

House connections for water shall be built to the meter vaults near the property line for all lots within a proposed development. All meters shall be placed in an outside vault and shall be Neptune Pro-read with automatic read disc placed in the lid. All adjacent improved lots which are not a part of the proposed development, but which may be served by the water line, shall be shown on the contract drawings.

### 2.5.2 Location

On the plans, indicate service connections 15 feet from the property line on the high end of the lot or at a location desired by the homeowner if the lot is already developed. Water meters in vaults shall be placed near the property line and shall not be constructed in the curb or sidewalk.

### 2.5.3 Sizing

- a. Service connections must be no smaller than 3/4 inches, the normal size for a residential dwelling. Twin house connections (3/4 inches each) will not be permitted in group and semi-detached developments to serve two adjacent houses.
- b. For other than a residential dwelling, determine the water supply demand pursuant to the criteria in Section 2.2. The velocity in the service connection must not exceed 8 fps.

### 2.5.4 Cover

Cover over service lines must be a minimum of 3 feet 6 inches or as required by the Frederick County Plumbing Code, whichever is greater.

### 2.5.5 Clearances

Water house services shall be placed 7 feet horizontally from sewer house connections and a minimum of 1 foot clear above the sewer house connection or as required by the Frederick County Plumbing Code.

#### 2.5.6 Materials

Piping material must be Type 'K' copper for residential service lines and ductile iron or copper for larger sizes.

#### 2.5.7 Cross Connections

No cross connections where contamination can enter the potable water supply are permitted. No cooling water or condensate may be returned to the potable water supply line. All interconnections shall be approved by the City and other appropriate reviewing authorities.

### 2.6 Appurtenances for Service Connections

#### 2.6.1 Meters (Location)

Meters shall be located near the property line inside a City standard meter vault.

#### 2.6.2 Meters (Sizing)

Meter types for Commercial, Industrial and Institutional applications shall be determined by the City or authorized agent. Meters shall be installed to record all water usage, including fire flow.

##### a. Valves

A valve or corporation cock shall be provided on the water main side of each meter installation.

##### b. Backflow Prevention Device

Reduced pressure backflow prevention devices shall be required on all services to commercial/industrial or individual facilities and shall be located immediately adjacent to the outlet side of the water meter, fully accessible. Refer to AWWA, *Cross Connection and Backflow Prevention* for additional design criteria.

#### 2.6.3 Installation

Installation of all service connections and appurtenances shall be in accordance with latest AWWA standards or manufacturer's recommendations. Such requirement shall be noted in specifications and on contract drawings.

#### 2.6.4 Booster Pumps

Booster Pumps may be permitted for individual domestic or fire flow service with the approval of the City. Their use, however, shall be discouraged and will only be considered on a case-by-case basis.

### 2.7 Distribution Mains

#### 2.7.1 Description

Distribution mains are 12 inches and smaller in diameter. For larger mains, design engineer should consult with the City regarding special design criteria.

#### 2.7.2 Location

##### a. In new subdivisions

Lay water mains 7 feet from the centerline of the road right-of-way, generally on the side of the road toward high ground (on opposite side of road from the sanitary sewer). Locate mains within the pavement area, wherever possible, no less than 5 feet from curb or proposed curb. Water mains shall not be located under curb or sidewalks, except where the water main crosses in a perpendicular fashion.

##### b. In existing developments with curbs

Generally, location must be the same as in new subdivisions. The location of other existing and proposed utilities must be fully considered.

##### c. In existing developments with pavement and no curbs

Generally, location must be the same as in new subdivisions. An alternative location with the approval of the City will involve locating the main 2 feet outside the edge of pavement on the opposite side of the road from the sanitary sewer, except that the main must not be laid under a future curb. The location of other existing and proposed utilities must be fully considered.

##### d. Where utilities are extended to accommodate development, they shall be extended across the full frontage of the property being serviced.

- e. In parks and public rights-of-way, where location of a water main would require removal of trees, the design engineer shall obtain approval of the City for tree removal.
- f. Distribution mains may be designed on a curved alignment to reduce the number of bends. Along curves, the water main may be deflected at each joint within the limits given in the Appendix.
- g. All water utility easements outside of road right-of-ways shall be 20 feet minimum width. No other utilities will be allowed in the water easement without the City's written approval.

#### 2.7.3 Size

- a. Distribution Mains

Shall be 8-inch minimum size and shall be interconnected at all intersecting streets, with valves on all mains at the intersection. Where the required flow exceeds the capacity of an 8-inch main or of the existing system, larger mains will be required.

- b. Distribution mains shall be sized to provide the required design flow rate and residual pressures as detailed herein.

- c. Transmission Mains

Sizing shall be based on a computerized network analysis performed by the design engineer or as provided by the City, if available.

#### 2.7.4 Materials

- a. All distribution and transmission mains and fittings shall be Ductile Iron, double cement lined (latest AWWA C-151) with standard mechanical joints or push-on joints.
- b. At bridge crossings, 16-inch and smaller ductile iron pipe shall have fiberglass insulation with vapor jacket wrapped by a full metal jacket for all exposed piping.
- c. Expansion joints, insulated couplings and rollers shall be provided as required.

#### 2.7.5 Installation

Installation of all service connections and appurtenances shall be in accordance with latest AWWA standards or manufacturer's recommendations. Such requirement shall be noted in specifications and on contract drawings.

#### 2.7.6 Cover Over Pipe

- a. Normal cover over water mains shall be 4 feet except at crossing over other utilities, where a minimal cover of 3 feet or a maximum cover of 9 feet may be allowed.

- b. In new subdivisions

Cover shall be measured from finished grade of road or as specified by the City. Roads shall be graded to subgrade before water mains are laid.

- c. In existing or ungraded roads

Established grades of roads shall be obtained from the City and are generally the proposed future finished grade. If such grades are not available, the design engineer shall submit proposed grades for approval by the City. If established grade is at or below existing surface, cover shall be measured from established grade. If established grade is above existing surface, cover shall be measured from existing surface. In no case, however, shall the cover deviate from the minimum or maximum cover indicated in 2.7.6.

#### 2.7.7 Clearances

- a. Clearances shall be measured between outside of pipes.

- b. Crossing Sanitary Sewer

Water main shall have minimum clearance of 18 inches above sewer. This vertical separation shall be maintained horizontally for a distance of 10 feet or as required by the Maryland Department of the Environment.

- c. Parallel to Sanitary Sewer

A horizontal distance of at least 10 feet shall separate water main and sewers or as required by the Maryland Department of the Environment.

- d. Crossing Other Utilities

Water mains shall have minimum clearance of 18 inches where crossing utilities.

EXCEPTIONS: When specified clearance is not physically possible between sewer and water in a new subdivision or in locations where sewer is built along roads having existing water mains, the sewers shall be designed according to Sewer Design Standards of Brunswick. If sewers already exist in a road, and water main cannot be built to specified clearances, ductile iron pipe with mechanical joints or other approved safety joints shall be used for the water mains. These installations shall be pressure tested to assure water tightness before backfilling. The City shall be consulted to discuss the use of concrete encasement of the sewer and/or water main. The Developer or Engineer shall propose options to the City for approval to ensure all possible measures are considered and implemented to avoid possible contamination of the water supply.

#### 2.7.8 Structural Considerations

a. Buttrresses and Anchors

Buttrresses and anchors shall be required at all fittings which achieve a change in pipeline direction, such as tees, fire hydrants, bends and dead ends, thrust restraint is necessary. Buttrresses and/or anchorage blocks are the two means of achieving thrust restraint. The design engineer shall decide what is appropriate for each particular situation based on an analysis of such factors as soil conditions, clearance requirements, constructability, future expansion and cost. Buttrresses and Anchorage blocks are concrete placed against undisturbed soil designed for restraint of thrust forces in pressurized piping systems. The City reserves the right to require a soils analysis.

b. Restrained Joints

If the soils at the project site are unusually poor, or other factors such as cost, space limitations, or future construction so indicate, restrained pipe joints shall be designed. The joint restraint may be either harnesses or mechanical joints with retainer glands for mains up to 16-inch diameter. Restrained joint types for larger mains shall be approved by the City prior to proceeding with design. The design shall account for test pressures, soil frictional resistance and effect of groundwater as a minimum. The City reserves the right to require a soils analysis.

c. Jacking and Tunneling

Where mains are being designed to cross railroads, state highways, or other roads, on which service cannot be interrupted, the water main shall be installed in a sleeve, tunneled or jacked under the road. The sleeve size

and material and the method of tunneling or jacking shall be approved by the owner of the road or the railroad being crossed.

The sleeve diameter shall be sufficient to permit the proper positioning of the water main within the sleeve. Water mains installed in sleeves shall have restrained joints throughout the length of the sleeve. The annular void between the main and the sleeve shall be completely filled with grout. Water mains installed in sleeves shall be equipped with sufficient valves to shut-off all flow through the sleeved section. In the case of dead end main, one valve upstream will be sufficient; in other cases, a valve at each end is required.

d. Design Loads and Pipe Design

In cases where deemed necessary by the City, the design engineer shall submit all calculations necessary to support the selection of the type and class of pipe indicated on the Contract Drawings.

The calculations may account for the following:

Vehicle or railroad loads (H-20, E-80, etc.);  
Pipe loading factors (dead, live, impact);  
Internal pressure (static, dynamic, surge);  
Installation trench configuration.

e. Corrosion Protection

If soil tests or inspection of existing utilities in the project area reveals evidence of, or potential for, corrosion, the City shall be notified of the condition. Should the City deem it necessary, the design engineer shall design suitable galvanic and/or cathodic corrosion protection measures using AWWA Controlling Corrosion Within Water Systems, 1978. The City reserves the right to require a soils analysis for corrositivity.

f. Deflection of Pipe

The maximum deflection allowed shall be as shown in Appendix B of this Manual.

2.8 Appurtenances for Service Mains

2.8.1 Valves

a. Size and Type

Mains 4-inches to 16-inches shall have valves of the same size as the main. Valves shall be resilient seat gate valves with non-rising stem. All valves 16-inches and larger shall have bevel gears and an enclosed gear case.

b. Location

Valves shall be installed on the loop or network at such places as to isolate the branch sections as may be necessary with a maximum spacing of 1500 feet. They shall be installed on all fire hydrant leads as close to the water main as is feasible. A valve shall be placed on all branch lines, regardless of size, near the main. Valves at intersections shall be placed on projection of road right-of-way lines. In no case shall the valve be placed in the sidewalk or less than ten feet (10') from another valve.

2.8.2 Tapping Sleeves and Valves

Where Used: Tapping sleeves and valves on ductile iron mains to serve as line valves shall be used for all connections 6-inches and larger to any existing main 12-inches or larger where more than 10 domestic services would be shut off during installation of a standard tee. The main being tapped may be the same size as the proposed main or tapping valve, but the tapping cutter shall be 1/4-inches or more undersized.

2.8.3 Fire Hydrants

a. Size and Type

Hydrant leads shall be a minimum of 6-inches. The engineer shall submit to the City a scale map 1 inch = 200 feet showing area streets, water mains and proposed location of fire hydrants for the City's use and for transmittal to the Fire Department. Fire hydrants shall be Mueller, Model A-423 or Kennedy Model K81. Each hydrant shall have one (1) 4½ inch diameter pump nozzle and two (2) 2½ inch hose nozzles, nozzle gaskets, 5¼ inch valve, 1½ inch pentagonal operating nut, open left. Both the hose nozzles and pumper nozzle shall have National Standard Thread. Hydrants shall be designed for 4½ foot bury and 6 inch mechanical joint inlet.

b. Location

Hydrants shall be located in a pattern approved by the City Engineer or his duly authorized representative and shall be located so as to provide vehicular clearance from the street. Hydrants not at intersections shall be located in relation to property lines in order to avoid interference with future driveways.

c. Spacing

Hydrant spacing in residential areas composed of detached or semi-detached one- and two-family dwellings shall be at each street intersection and at 500-foot maximum intervals between intersections. Hydrant spacing in other residential areas and all other uses of property shall be at each street intersection and at 300-foot maximum intervals between street intersections.

2.8.4 Air and Vacuum Release Valves

- a. The proper ventilation of distribution and transmission mains is often overlooked by design engineers. Trapped air pockets can significantly reduce the capacity of the mains as well as cause increased pumping heads and corresponding higher pumping costs. The following guidelines shall be used to locate air and vacuum release valves:

Peaks in profiles

Abrupt increase in downward slope

Abrupt decrease in upward slope

Long ascents - 1500 ft to 3000 ft intervals

Long descents - 1500 ft to 3000 ft intervals

Long horizontals - 1500 ft to 3000 ft intervals

Pumps - on the discharge side of pump having suction as close to the check valve as possible

- b. In general, fire hydrants shall be placed at all high points along the main and at the terminus of dead end mains.

2.8.5 Valve Vaults

- a. Mains 12 Inches and Smaller

For valves and for tapping sleeves and valves, use the Frederick County Standard Roadway Valve Box.

- b. Mains Larger than 12 Inches

For valves, except butterfly-type, use reinforced concrete vaults as approved by the City. For tapping tees and valves, use concrete vaults as approved by the City.

2.9 Testing and Disinfection

The contract documents shall provide for hydrostatic testing of newly laid mains as described in the Frederick County Standard Specifications. Hydrostatic tests shall be performed for pressure retention and leakage. Disinfection shall be in accordance with AWWA C-651.

## 2.10 Abandonment Procedures

Abandoned service connections shall be cut and plugged at the service main, and the meters removed and salvaged if their condition permits reuse. Distribution mains that are to be abandoned shall be plugged at the point of abandonment and on each side of any existing valves, and the valves and hydrants removed and salvaged if their reuse appears practicable. Any necessary buttresses or anchorage required shall be designed in accordance with Frederick County Standard Details.

## 2.11 Water Pumping and Treatment

A detailed presentation of design criteria for pumping and treatment facilities is beyond the scope of this manual. The City will specify the exact requirements to be met by the design of these facilities.

## 2.12 Water Storage

### 2.12.1 General

A water system must be able to meet the peak hour demand during the maximum demand day to be effective. However, it is not economically feasible for domestic water systems to provide sufficient supply capacity to meet these peak demands. Therefore, to stabilize pressure and also to provide the necessary reserve capacity to meet peak demand period, it is the usual practice to provide storage reservoirs as an integral part of any distribution system.

During periods of peak demand, such as fire conditions, the required volumes of water that cannot be provided from the system's supply source are taken from the system's distribution storage. During periods of low demand, the excess water from the supply source returns to storage until the facilities are again full, completing the cycle.

The criteria used to determine the proper size of storage facilities can best be understood in terms of the functions which storage facilities are intended to perform. These functions may be summarized as follows:

- a. To provide an equalizing reserve.
- b. To provide a fire reserve.

- c. To provide an emergency reserve.

#### 2.12.2 Equalizing Storage

The equalizing reserve is the quantity of water needed to even out or "equalize" the system demands during a day's operation. By providing this reserve, the storage facilities make it possible to operate the treatment facilities and pumping stations at a relatively uniform rate. When the system demand is higher than the supply rate, water is withdrawn from the storage facilities. Conversely, when the system demand is below the supply rate, water is returned to storage to ensure that an adequate quantity is available for the next period of high demand. In general, systems which have an equalizing reserve equal to 20% of their maximum daily demand operate satisfactorily.

#### 2.12.3 Fire Reserve

The size of the fire reserve is indirectly set by the Insurance Services Office (ISO), formerly known as the National Board of Fire Underwriters. This agency sets standards for the amount of fire flow that should be available at various points in a community.

#### 2.12.4 Emergency Reserve

The emergency reserve is included as a safeguard against disruptions in the supply source, ruptured water mains, well-pump interruptions, or other circumstances which would exert an additional demand on the storage facilities. Normally, the quantity allotted for emergencies is 25% of the total effective storage volume.

### 2.13 Repaving of Roads

#### 2.13.1 General

- a. All City construction contract specifications shall include a "patch-pave" requirement as follows:

Properly compacted borrow aggregate backfill shall be placed and compacted from 3 inches below the pipe to the bituminous pavement subgrade. The pavement replacement shall consist of a base course of asphaltic concrete of at least a thickness equivalent to the original pavement section, the original wearing course cut back two-feet on all edges of the excavation and a new asphaltic concrete wearing course of at least a thickness equivalent to the original wearing course. Other road pavement sections will receive similar treatment. In all cases, however, the base course shall be a minimum of 4 inches, and the wearing course shall be a minimum of 2 inches.

- b. Patch-paving as outlined above is to be accomplished whether the roadway is to be re-paved or not.
- c. House connection installations will require the same specifications for patch-paving.
- d. All paving/repaving work will be accomplished in accordance with the City Road Specifications or Design Manual. A "road cut" permit must be obtained from the City when excavating within an existing City-maintained roadway.
- e. Pavement patch in County or State roads shall comply with the requirements of the jurisdiction.

#### 2.13.2 Timing of Patch-paving and/or Repaving

- a. Specifications will provide that patch-paving shall be accomplished immediately after backfilling and achieving specified compaction for connection and small extension contracts; and at no greater than seven (7) calendar day intervals for larger projects. Temporary "cold patch" shall be required for patches not immediately patch-paved. The City must be consulted if immediate patch-paving cannot be accomplished. Cold patching must be maintained by the Developer to the City's satisfaction. The placement of steel plates over trenching may be approved by the City on a case-by-case basis.
- b. Repaving shall be specified to be accomplished in one continuous effort to best assure economy and consistency of quality work.

#### 2.13.3 Traffic Control

All water utility construction projects shall have an approved traffic control plan, using requirements of the Manual on Uniform Traffic Control Devices.

### 3.0 CONTRACT DRAWINGS AND DOCUMENTS

#### 3.1 Reports

For mains larger than 12-inches, three copies of a preliminary report shall be submitted to the City. The report shall include a sketch of the preliminary layout and a summary of the design data.

#### 3.2 Design Computations

- a. Design engineers shall submit three copies of design data and calculations for all water projects. The computations shall be in accordance with methods presented in this manual.
- b. The design data and computations shall include: average and peak demands, fire demand, and future requirements.
- c. Design computations for all special structures shall be submitted. Where information pertinent to design, such as borings, has been collected, this information shall be submitted to the City. The locations of borings shall be shown on the plan sheets, and the boring logs shall be included in the Contract Documents. See Appendix F for Geo-Technical Requirements. In addition, the City reserves the right to require borings and geotechnical information.

### 3.3 Specifications

Contract specifications shall utilize the City of Brunswick Specifications or, in the absence of City Specifications, the Frederick County Specifications will apply.

### 3.4 Contract Drawings

#### 3.4.1 Preparation

Water main contract drawings shall be prepared on drawings separate from drawings detailing the road design. Separate drawings shall be used for each street.

#### 3.4.2 Plan

- a. Scale: 1 inch = 50 feet.
- b. Method of Indicating Location

Generally, water mains and structures shall be located in Plan by dimensions from property markers or other well-defined physical features. However, in areas where physical features are not available, coordinates of structures and bearings of water mains based on the Maryland Coordinate System NAD 83/91 shall be used.

- c. Fittings

A list of all valves and fittings required shall be shown on each drawing.

- d. Contract drawings shall include the property line surveys and all lot dimensions of the land bordering water extensions and shall indicate the

names of the present owners of such property with the recording reference number of the deed, lot numbers, house numbers, subdivision names and block numbers, as well as existing rights-of-way or easements. When rights-of-way must be obtained, a right-of-way drawing for each property shall be provided, accompanied by a written description of each right-of-way.

### 3.4.3 Profile

Profiles shall be shown for all water mains. Profile shall be on same sheet as the Plan.

#### a. Scale

Scale of all profiles shall be 1 inch = 50 feet horizontal; 1 inch = 5 feet vertical. Water main profiles on straight streets shall be shown to correct scale. On curved streets, horizontal distances between structures shall be plotted using length of street centerline between radial projections to structures. The true length between structures shall be shown by figures.

#### b. Road Grades

Approved established grades shall be obtained from the City. When such grades are not available, they shall be established by the design engineer and submitted to the City for approval.

The established grade (noted as top of curb or centerline) shall be shown. Where water main is located in present or proposed pavement or shoulders, the existing centerline grade of road shall be shown. Where water main is outside pavement or shoulders for a length greater than 50 feet, existing ground over water main shall be shown and labeled.

#### c. Water Main on Fill

Where water main is to be constructed on fill, a profile of the undisturbed earth (at water main location) shall be shown.

### 3.4.4 Other Utilities

Other existing and proposed utilities shall be shown accurately and clearly in Plan and Profile.

### 3.4.5 Location and Design Information

A Location Plan showing well known streets at a scale of 1 inch = 200 feet shall appear on the first drawing of each set of Contract Drawings. A schematic layout of the proposed extensions to the water system and adjacent existing lines shall be shown. The location of existing valves which must be shut off when the new line is connected must be shown. Existing and proposed fire hydrants shall also be shown.

#### 3.4.6 Special Details

Structures or details not included in the Standard Details shall be detailed clearly on the Contract Drawings, preferably where the detail is located in Plan.

- 3.4.7 As-Built drawings are required to be submitted with the Request for Conditional Acceptance in addition to the Request for Final Acceptance for review and approval. Once approved, the appropriate number of the As-Built drawings on mylar plan sheets with the statement and Engineer's signature, as shown in the Appendix, and City Approval Block shall be submitted to City Hall prior to Final acceptance of the work by the City and on computer or GIS diskette in a format approved by the City Public Works, City Engineer, and the Office of Planning and Zoning.

#### 3.5 Estimate of Project Costs

The engineer shall submit an estimate of project costs for each contract, including contingent items and a 15% contingency based on the total cost of the project.

# APPENDIX A

## BASIS FOR RESIDENTIAL WATER DEMAND PROJECTIONS FOR UNDEVELOPED OR PARTIALLY DEVELOPED AREAS

Zoning	Projected Population per Acre	Projected Dwelling Units per Acre	Projected Demand Avg Per Acre Based on 200 GPD/dwelling Factor	Maximum Day Peaking Factor	Maximum Day Demand GPD/Acre
AG (Agricultural)	2.6	1	200	2.0	400
RS (Residential Suburban Low Density)	10.4	4	800	2.0	1600
R-1 (Low Density Residential)	18.2	7	1400	2.0	2800
R-2 (Medium Density Residential)	23.4	9	1800	2.0	3600

	Projected Flow per Acre	Avg Day Peaking Factor	Maximum Day Demand GPD/Acre
COMMERCIAL: B-1, B-2, B-3, GC, HS	*500	1.4	700
LIGHT INDUSTRIAL : I-1, OR	*500	1.3	650
HEAVY INDUSTRIAL: I-2	*1000	1.1	1100

\*Use Appendix D when the specific type of development is known. Use Frederick County Plumbing Code when a specific fixture count is known.

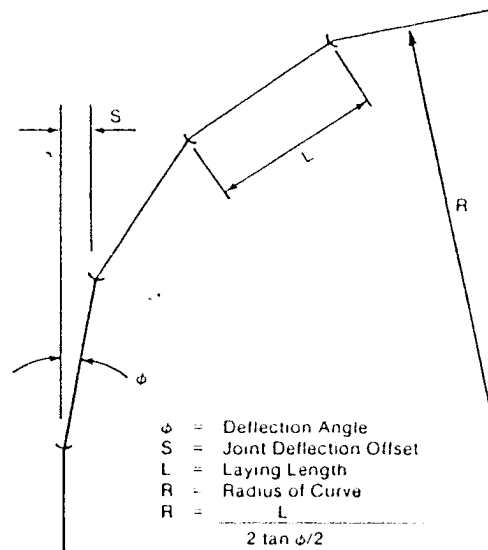
# APPENDIX B MAXIMUM JOINT DEFLECTIONS FOR PIPE

## *Maximum Joint Deflection\* Full-Length Pipe—Push-On Type Joint*

Nominal Pipe Size <i>in</i>	Deflection Angle - $\theta$ <i>deg</i>	Maximum Offset $S^\dagger$ <i>in (m)</i>		Approx. Radius of Curve - $R^\dagger$ Produced by Succession of Joints <i>ft (m)</i>	
		18 ft (5.5 m) <i>L†</i>	20 ft (6.1 m) <i>L†</i>	18 ft (5.5 m) <i>L†</i>	20 ft (6.1 m) <i>L†</i>
3	5	19 (0.48)	21 (0.53)	205 (62)	230 (70)
4	5	19 (0.48)	21 (0.53)	205 (62)	230 (70)
6	5	19 (0.48)	21 (0.53)	205 (62)	230 (70)
8	5	19 (0.48)	21 (0.53)	205 (62)	230 (70)
10	5	19 (0.48)	21 (0.53)	205 (62)	230 (70)
12	5	19 (0.48)	21 (0.53)	205 (62)	230 (70)
14	3*	11 (0.28)	12 (0.30)	340 (104)	380 (115)
16	3*	11 (0.28)	12 (0.30)	340 (104)	380 (115)
18	3*	11 (0.28)	12 (0.30)	340 (104)	380 (115)
20	3*	11 (0.28)	12 (0.30)	340 (104)	380 (115)
24	3*	11 (0.28)	12 (0.30)	340 (104)	380 (115)
30	3*	11 (0.28)	12 (0.30)	340 (104)	380 (115)
36	3*	11 (0.28)	12 (0.30)	340 (104)	380 (115)
42	2*	7½ (0.19)	8 (0.20)	510 (155)	570 (174)
48	2*	7½ (0.19)	8 (0.20)	510 (155)	570 (174)
54	1½*	5½ (0.14)	6 (0.15)	680 (207)	760 (232)

\*For 14-in. and larger push-on joints, maximum deflection angle may be larger than shown above. Consult manufacturer.

†See Figure 4

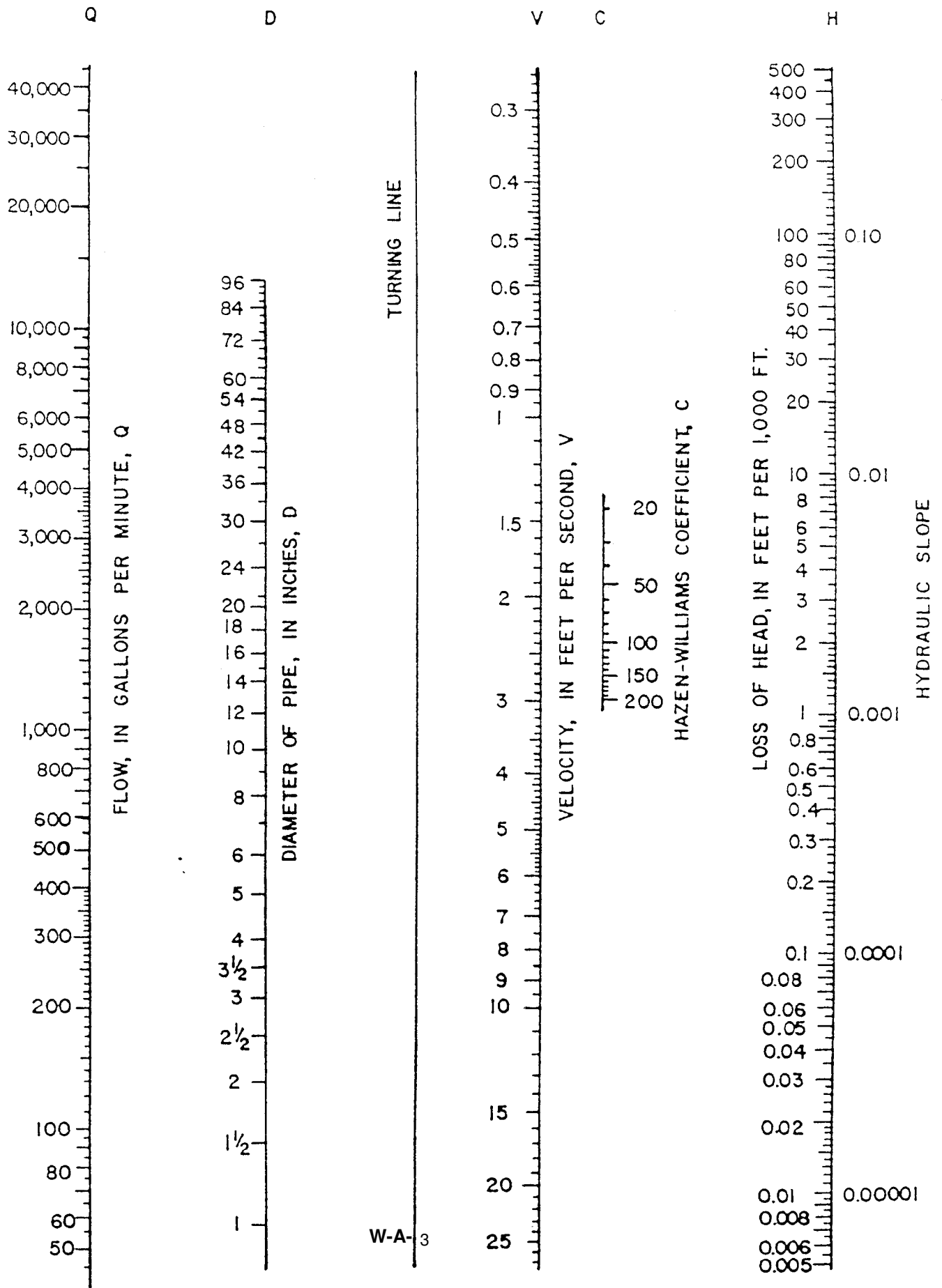


## *Maximum Joint Deflection Full-Length Pipe—Mechanical-Joint Pipe*

Nominal Pipe Size <i>in</i>	Deflection Angle - $\theta$ <i>deg</i>	Maximum Offset $S^*$ <i>in (m)</i>		Approx. Radius of Curve - $R^*$ Produced by Succession of Joints <i>ft (m)</i>	
		18 ft (5.5 m) <i>L*</i>	20 ft (6.1 m) <i>L*</i>	18 ft (5.5 m) <i>L*</i>	20 ft (6.1 m) <i>L*</i>
3	8-18	31 (0.79)	35 (0.89)	125 (38)	140 (43)
4	8-18	31 (0.79)	35 (0.89)	125 (38)	140 (43)
6	7-07	27 (0.69)	30 (0.76)	145 (44)	160 (49)
8	5-21	20 (0.51)	22 (0.56)	195 (59)	220 (67)
10	5-21	20 (0.51)	22 (0.56)	195 (59)	220 (67)
12	5-21	20 (0.51)	22 (0.56)	195 (59)	220 (67)
14	3-35	13½ (0.34)	15 (0.38)	285 (87)	320 (98)
16	3-35	13½ (0.34)	15 (0.38)	285 (87)	320 (98)
18	3-00	11 (0.28)	12 (0.30)	340 (104)	380 (116)
20	3-00	11 (0.28)	12 (0.30)	340 (104)	380 (116)
24	2-23	9 (0.23)	10 (0.25)	450 (137)	500 (152)
30	2-23	9 (0.23)	10 (0.25)	450 (137)	500 (152)
36	2-05	8 (0.20)	9 (0.23)	500 (152)	550 (167)
42	2-00	7½ (0.19)	8 (0.20)	510 (155)	570 (174)
48	2-00	7½ (0.19)	8 (0.20)	510 (155)	570 (174)

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# APPENDIX C HAZEN-WILLIAMS NOMOGRAPH



## APPENDIX D

### GUIDELINES FOR DEVELOPING WATER DEMAND PROJECTIONS FOR COMMERCIAL ESTABLISHMENTS OR PUBLIC BUILDINGS

Office Buildings . . . . .	Gross Sq. Ft. x 0.09 = gpd
Medical Office Buildings . . . . .	Gross Sq. Ft. x 0.62 = gpd
Warehouses . . . . .	Gross Sq. Ft. x 0.03 = gpd
Retail Stores . . . . .	Gross Sq. Ft. x 0.05 = gpd
Supermarkets . . . . .	Gross Sq. Ft. x 0.20 = gpd
Drug Stores . . . . .	Gross Sq. Ft. x 0.13 = gpd
Beauty Salons . . . . .	Gross Sq. Ft. x 0.35 = gpd
Barber Shops . . . . .	Gross Sq. Ft. x 0.20 = gpd
Department Store with Lunch Counter . . . . .	Gross Sq. Ft. x 0.08 = gpd
Department Store without Lunch Counter . . . . .	Gross Sq. Ft. x 0.04 = gpd
Banks . . . . .	Gross Sq. Ft. x 0.04 = gpd
Service Stations . . . . .	Gross Sq. Ft. x 0.18 = gpd
Laundries and Cleaners . . . . .	Gross Sq. Ft. x 0.31 = gpd
Laundromats . . . . .	Gross Sq. Ft. x 3.68 = gpd
Car Wash without Wastewater Recirculation Equipment . . . . .	Gross Sq. Ft. x 4.90 = gpd
Hotels . . . . .	Gross Sq. Ft. x 0.25 = gpd
Motels . . . . .	Gross Sq. Ft. x 0.23 = gpd
Dry Goods Stores . . . . .	Gross Sq. Ft. x 0.05 = gpd
Shopping Centers . . . . .	Gross Sq. Ft. x 0.18 = gpd
Hospitals (per bed space) . . . . .	350 Gallons/per bed space/day = gpd
Nursing homes (per bed space) . . . . .	125 Gallons/per bed space/day = gpd
Restaurants (per seat) . . . . .	5 Gallons/seat/day = gpd
Schools:	
Boarding . . . . .	100 Gallons/per person/day = gpd
Day, without gyms, cafeterias or showers . . . . .	15 Gallons/per person/day = gpd
Day, with gyms, cafeterias and showers . . . . .	25 Gallons/per person/day = gpd
Day, with cafeterias but without gyms or showers . . . . .	20 Gallons/per person/day = gpd

## APPENDIX E

### MINOR LOSSES OF HEAD IN EQUIVALENT LENGTHS

<u>Nature of Resistance</u>	<u>Loss in Pipe Diameters</u>
Angle Valve	
Open	170
Check Valve	
Swing Type, Open	80
Gate Valve	
Wide Open	7
$\frac{1}{4}$ Closed	40
$\frac{1}{2}$ Closed	200
$\frac{3}{4}$ Closed	850
Globe Valve	
Open	340
Standard Elbow	32
Long Swing Elbow	20
45-Degree Elbow	15
Tee	
Flow Through Run	20
Flow Side to Run or Run to Side	
No Throat	66
With Throat	45
Lateral	45
Sudden Contraction	
$d/D = \frac{1}{4}$	15
$d/D = \frac{1}{2}$	12
$d/D = \frac{3}{4}$	7
Sudden Enlargement	
$d/D = \frac{1}{4}$	32
$d/D = \frac{1}{2}$	20
$d/D = \frac{3}{4}$	7

AS-BUILT DRAWING

I HEREBY STATE, TO THE BEST OF MY  
KNOWLEDGE AND PERSONAL BELIEF, THAT  
THE WORK SHOWN ON THESE PLANS WAS  
CONSTRUCTED TO THE LINES AND GRADES  
SHOWN.

\_\_\_\_\_  
ENGINEER          DATE          P.E. NO.

AS-BUILT DRAWING  
STATEMENT  
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CITY OF BRUNSWICK